
“Hybrid solar cells with thermal deposited semiconductive oxide layer”

Claims

1. Method for the production of a hybrid organic solar cell comprising introducing the semiconducting oxide layer (SOL) by thermal deposition.
2. Method for the production of a hybrid organic solar cell according to claim 1, characterised in that the SOL layer is vapor-deposited.

3. Method for the production of a hybrid organic solar cell having the general structure

Substrate + EM/HTM/dye/SOL/EM, or

Substrate + EM/SOL/dye/HTM/EM, or

Substrate + EM/HTM/SOL/EM, in which

EM is the electrode material, selected from the group comprising of a transparent conductive oxide (TCO) and metal, with at least one of the EM layer(s) of the cell being a TCO,

HTM is the hole transport material,

SOL is a semiconducting oxide layer,

“dye” means a suited dye,

comprising vapor-deposition of the SOL layer of the hybrid organic solar cell.

4. Method for the production of a hybrid organic solar cell according to claim 3, comprising vapor-deposition of at least one second layer of the hybrid organic solar cell in addition to the SOL layer.

5. Method according to any of claims 1 to 4, comprising deposition and/or vapour-deposition of an additional layer of lithium fluoride close to the EM interfaces either on one side or both sides.
6. Method according to claim 5, characterised in that the additional layer has a thickness of between about 0.1 Å to about 50 Å.
7. Method according to any of claims 1 to 6, comprising increasing the surfaces of the interfaces of the layers by use of structured ITO, co-evaporation of HTM and dye and/or dye/TiO₂ or co-evaporation of HTM and a dopant.
8. Method according to any of claims 1 to 7, characterised in that the substrate is selected from the group comprising glass, coated glass, polymeric foils, like foils made from PET, PEN or PI, norbornene-based foils, SnO₂-coated metal foils or stainless steel foils.
9. Method according to any of claims 1 to 8, characterised in that the substrate is flexible.
10. Method according to any of claims 1 to 9, characterised in that EM is selected from the group comprising indium tin oxide, fluorine doped tin oxide, zinc oxide or doped zinc oxide and metal, like Au, Al, Ca or Mg or combinations of metals like Al/Li, Mg/Ag and the like.
11. Method according to any of claims 1 to 10, characterised in that EM is indium tin oxide.
12. Method according to any of claims 1 to 11, characterised in that HTM is selected from the group comprising of phthalocyanine and derivatives thereof (with or without a central atom or group of atoms), metal-free and metal containing porphyrins and derivatives thereof, TPD derivatives, triphenylamine and its derivatives, (including different ground structure as TDA-TAs, TTABs, TDABs, and cyclic variations like N-carbazoles and its derivatives), thio-phenes, polythiophenes and derivatives thereof, polyanilines and derivatives thereof and hexa-benzocoronene and its derivatives, triphenyldiamine derivatives, aromatic diamine com-

pounds having connected tertiary aromatic amine units of 1,-bis(4-(di-p-tolylamino)phenyl)-cyclohexane, aromatic diamines containing two or more tertiary amines and having two or more fused aromatic rings substituted on the nitrogen atoms as typified by 4,4-bis[(N-1-naphthyl)-N-phenylamino]-biphenyl, aromatic trimers having a starburst structure derived from triphenylbenzene, aromatic diamines such as N,N'-diphenyl-N,N'-bis(3-methyphenyl)-(1,1'-biphenyl)-4,4'-diamine, $\alpha,\alpha,\alpha',\alpha'$ -tetramethyl- α,α' -bis(4-di-p-tolylaminophenyl)-p-xylene, triphenylamine derivatives whose molecule is sterically asymmetric as a whole, compounds having a plurality of aromatic diamino groups substituted on a pyrenyl group, aromatic diamines having tertiary amine units connected through an ethylene group, aromatic diamines having a styryl structure, starburst type aromatic triamines, benzyl-phenyl compounds, compounds having tertiary amine units connected through a fluorene group, triamine compounds, bisdipyridylaminobiophenyl compounds, N,N,N-triphenylamine derivatives, aromatic diamines having a phenoxazine structure, diaminophenylanthridine, and other carbazole derivatives, hydrazoen compounds, silazane compounds, silanamine derivatives, phosphamine derivatives, quinacridone compounds, stilbene compounds such as 4-di-p-tolylamino-stilbene and 4-(di-p-tolylamino)-4'-[4-di-p-tolylamino)-styryl]stilbene, triazole derivatives, oxadiazole derivatives, imidazole derivatives, polyarylalkane derivatives, pyrazoline derivatives, pyrazolone derivatives, oxadiazole derivatives, imidazole derivatives, polyarylalkane derivatives, pyrazoline derivatives, amino-substituted chalcone derivatives, oxazole derivatives, styrylanthracene derivatives, fluorenone derivatives and polysilane derivatives, all compounds alone or in admixture of two or more, polymers, like polyvinyl carbazole and polysilanes, polyphosphazenes, polyamides, polyvinyl triphenylamine, polymers having a triphenylamine skeleton, polymers having triphenylamine units connected through a methylene group and polymethacrylates containing aromatic amine, preferably having an average molecular weight of at least 1,000, more preferably at least 5,000.

13. Method according to any of claims 1 to 12, characterised in that HTM is copper-phthalocyanine (CuPc).

14. Method according to any of claims 1 to 13, characterised in that SOL is selected from the group comprising semiconducting oxides, like TiO_2 , SnO_2 , ZnO , Sb_2O_3 , and PbO .

15. Method according to any of claims 1 to 14, characterised in that SOL is TiO_2 .

16. Method according to any of claims 1 to 15, characterised in that the dye is selected from the group comprising of di- or monosubstituted perylenes with all possible substituents, e.g. perylene anhydrid, perylene dianhydrides, perylene imides, perylene diimides, perylene imidazoles, perylene diimidazoles and derivatives thereof, terrylene, quinacridone, anthraquinone, nealred, titanylphthalocyanine, porphines and porphyrines and derivatives thereof, polyfluorenes and derivatives thereof and azo-dyes.
17. Method according to any of claims 1 to 16, characterised in that the dye layer is deposited in a thickness of about 5 to about 65 nm and the SOL layer is deposited in a thickness of about 5 to about 50 nm.
18. Method according to any of claims 1 to 17, characterised in that more than one dye is used in one cell.
19. Method according to any of claims 1 to 18, characterised in that the substance of the HTM is doped.
20. Use of an vapour deposited additional semiconductive oxide layer to improve the efficiency of organic solar cells.
21. Hybrid solar cell, obtainable by to a method according to any of claims 1 to 19.
22. Hybrid solar cell according to claim 21 with a thickness of the complete cell of about 100 nm.
23. Hybrid solar cell according to any of claims 21 and 22 with an efficiency of about 0.7 to about 1.3 % measured at 60 mW/cm².
24. Hybrid solar cell according to any of claims 21 to 23, which is flexible.